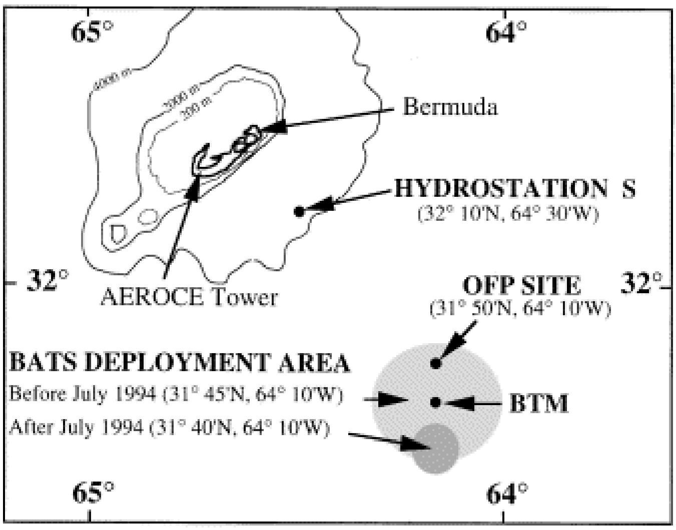

Bermuda Atlantic Time-series Study

The primary station is located at 31°50'N, 64°10'W approximately 82 km SE of St. David's Light, Bermuda in 4500 m of water. The Bermuda Atlantic Time-series Study (BATS) station operates since October 1988 and is representative of the western North Atlantic subtropical gyre (Sargasso Sea).

The current JGOFS sampling program builds on the nearby Hydrostation 'S' (32°10'N, 64°30'W) initiated in June 1954, but current BATS sampling is conducted at a new station approximately three times the distance from shore to eliminate any biogeochemical influences of the coastal zone. The interdisciplinary station work includes physical, chemical and biological observations and rate measurements. A bottom-moored sediment trap program located near the current BATS site began in 1976, and independent physical-biogeochemical mooring and atmospheric samplings presently complement the BATS program, which includes approximately biweekly to monthly field observations, operated by the Bermuda Biological Station for Research (BBSR).

The potential for acquiring more diverse and detailed time-series data was a key motivator in allowing BBSR to establish the Bermuda Atlantic Time-series Study. The BATS team is involved in making monthly measurements of important hydrographic, biological and chemical parameters throughout the water column at sites within the Sargasso Sea. Collaborative research efforts in the Sargasso Sea between BATS and other institutions include the Oceanic Flux Program (OFP), a continuing time-series study of sediment transport measurements into the deep sea (WHOI), and the Bermuda Testbed Mooring site, where the latest high-technology moored platform is combined with hydrographic and bio-optical sensors (USC, UCSB, MBARI, LDEO). The Bermuda Bio-Optics Project (BBOP) explores the relationship between light and upper ocean biogeochemistry and provides the "optical link" between the BATS biogeochemistry measurements and the satellite ocean color imagery (e.g., SeaWiFS). The Bermuda Testbed Mooring (BTM) has been deployed since June 1994 and provides the oceanographic community with a deep-water platform for developing, testing, calibrating, and intercomparing instruments. The mooring is located ~80 km southeast of Bermuda. Instruments are being used to collect meteorological and spectral radiometric measurements from a buoy tower. Subsurface measurements include currents, temperature, conductivity, several inherent and apparent optical properties, and nitrate and trace element concentrations. The high temporal resolution, long-term data collected from the mooring provide important information concerning episodic and periodic processes ranging in scale from minutes to years, and not resolvable in the shipboard dataset. Evaluation of undersampling and aliasing effects characteristic of infrequent sampling are also enabled with these data sets.

BATS is proving invaluable in the arena of environmental science by producing data to better understand global climate change and the oceans' responses to variations in the atmosphere. The BATS team is committed to maintaining its leading role in the field of oceanography and educating future scientists in an environment at the forefront of scientific discovery.

Overview of BATS Research

Scientific investigation often generates as many questions as it answers. This has been particularly true in the area of oceanography. Big-picture questions (such as "*How does the ocean react to global climate change, and what role does it play in ecosystem balance?*") can be answered by in-depth analysis of data collected over a significantly long period of time. The Bermuda Atlantic Time-series Study (BATS) was established to uncover mysteries of the deep by analyzing important hydrographic and biological parameters throughout the water column. Pursuing this goal has enabled BATS scientists — and oceanographers worldwide — to completely revise their perspective on the ocean's physical, chemical and biological processes. Sustained time-series data collection has challenged longstanding paradigms and has begun to uncover exciting new observations about the ocean. In particular, BATS and other deep-ocean time-series studies have highlighted the importance of biological diversity in understanding biological and chemical cycles. Biological diversity in the ocean results in a diverse array of metabolic processes, and consequently varied methods for the turnover of dissolved organic carbon, for example. BATS scientists have also focused on carbon exchange between the oceans and atmosphere, seeking an understanding of how oceans respond to the clear impact of humans on atmospheric carbon dioxide. Carbon removal pathways from the surface ocean that were poorly quantified a decade ago — "active carbon transport" by migrant zooplankton and food web influences — have emerged as significant terms of the Biological Carbon Pump. After 14 years of data collection, we can now show that there are links between major biogeochemical parameters in the Sargasso Sea and low-frequency climate patterns, such as the El Niño-Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO).

Some Significant Findings of the BATS Program

Mesoscale eddies: are a significant physical feature where BATS samples in the Sargasso Sea. Eddies are contiguous physical features that propagate through the area of the BATS study site and as such impart an additional level of "variability" on many of the parameters that we measure on a monthly basis. There are several types of eddies and they are broken into two groups depending upon if they raise seawater density layers closer to the surface, thereby bring nutrients into the sunlit region of the ocean, or if they depress seawater density layers. Both of these eddy types have significant, but poorly understood impacts on phytoplankton community structure and the sequestration of carbon in the ocean interior.

Multi-year increase in CO_2 concentrations: in the surface ocean has now been conclusively documented. At the beginning of BATS, it was hypothesized that the inorganic carbon dioxide concentrations in the surface ocean would increase as the concentrations increased in the atmosphere, but detection of this increase would be "masked" by the large seasonal changes in carbon dioxide. Fourteen years of high-quality measurements have now shown that surface carbon dioxide concentrations are in fact increasing. How the biological system will respond to this increase, however, is much less clear. Different phytoplankton groups have different affinities for carbon dioxide and also have varying efficiencies with which they remove this carbon into the ocean interior.

Dissolved organic carbon (DOC): is now quantified as the largest exchangeable carbon pool in the ocean and at BATS has been shown to be a seasonally important carbon sequestration term. Beyond DOC, dissolved organic nitrogen (DON) and phosphorus (DOP) pools are the largest pools of nitrogen and phosphorus in the surface ocean. Understanding how all of these organic elemental cycles vary with respect to each other has a significant impact on not only the long-term storage of DOC but also potentially the assimilation of carbon dioxide.

Implications

Physical processes at a variety of temporal and spatial scales impact biogeochemical cycling of key elements in the ocean concurrently. With regard to long-term global change, the oceans can be thought of in terms of regional provinces that are impacted by regional, low-frequency physical forces, such as the North Atlantic Oscillation that governs long-term the North Atlantic climate. So although each year in the northern temperature latitudes is characterized by a seasonal cycle, the NAO in part determines the extent to which winters can be warmer or cooler than the average. Understanding of how these low-frequency physical forces impact biogeochemical cycling is key to predicting future changes within the ocean.

Current BATS Research Team (2003)

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Michael Lomas, Assistant Research Scientist; Rod Johnson, data management; Nathaniel Buck, microbiology and data management; Paul Lethaby, data management; Keven Neely, particulate elemental analysis; Debra Clougherty, nutrient analysis; Megan Roadman, dissolved oxygen, salinity, zooplankton; Vivienne Lochhead, HPLC pigments.

BATS and Hydrostation "S" datasets are available at **www.bbsr.edu**, approximately one year after collection, along with annual data reports, published and distributed through the US JGOFS Office.
Visit **ftp://ftp.bbsr.edu/bats/** for BATS and Hydrostation data, or contact P. Lethaby <**paul@bbsr.edu**>.

For further information, see the official BATS website at: **www.bbsr.edu/cintoo/bats/bats.html.**